

# Sampling and Analysis Plan

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This appendix describes the methods and procedures that will be used during the phased sampling programs described in Section 4 of the Tittabawassee River and Floodplain Remedial Investigation (RI) Work Plan (RIWP).

## Summary of Sampling and Analysis Programs

The sampling programs associated with Phase I of the RI are summarized below:

- **Tittabawassee River Study Area Samples for Potential Constituents of Interest (PCOI) Identification:**
  - Soil – 60 sample locations distributed throughout the estimated 100-year Floodplain
    - 60 surface soil samples
    - 60 subsurface soil samples
  - Sediment – 25 sample locations systematically distributed along length of river from The Dow Chemical Company (Dow) property to the Confluence Area
    - 25 surface sediment samples
    - 25 to 75 subsurface sediment samples, depending on thickness of unconsolidated sediment at each location
  - Surface water – a total of six samples consisting of flow-integrated samples collected at three locations along the river during normal spring flow and during a high flow event. Sampling under normal spring flow conditions will target a flow of approximately 3,000 cubic feet per second (cfs) as reported at the U. S. Geological Survey (USGS) Midland gage, which corresponds to the March/ April median (50th percentile) flow condition. High flow sampling will target a 1-year recurrence interval flow event occurring in response to wet weather. This flow corresponds to approximately 10,000 cfs as reported at the USGS Midland gage. The samples will be divided into dissolved and suspended solids fractions for analysis.
- **Reference Area Samples for Development of Background Threshold Values:**
  - Soil – 30 sample locations distributed among two reference areas (Emerson Park and Chippewa Nature Center):
    - 30 surface soil samples
    - 30 subsurface soil samples
  - Sediment – 30 sample locations distributed between the Chippewa and Upper Tittabawassee Rivers:

- 30 surface sediment samples
  - 30 subsurface sediment samples
- Surface water– a total of four samples consisting of flow-integrated samples collected from the Chippewa and Upper Tittabawassee Rivers during normal spring flow and during a high flow event.
- **8-Year Floodplain Boundary Samples:**
  - 60 surface soil locations
- **Completion of Floodplain Scoping Study Sampling in Area 3 and Confluence Area**
  - Surface soil - 43 locations in Area 3 and 17 locations in the Confluence Area.
  - Subsurface soil – three locations in Area 3 and three locations in the Confluence Area. The number of samples depends on the thickness of the floodplain deposits at each location.
  - Geochronological soil – three locations in Area 3 and seven locations in the Confluence Area.
  - Dendrogeomorphic measurement – one location area in Area 3 and eight location areas in the Confluence Area.
- **Geomorphic Feature Sampling**
  - 240 surface soil sample locations (20 locations per geomorphic feature, four features per area, three areas)
  - 60 subsurface soil sample locations (five locations per geomorphic feature, four features per area, three areas). Number of samples depends on thickness of floodplain deposits at each location
- **Fractionated Grain Size Sampling**
  - 36 surface soil sample locations (three areas, four geomorphic features per area, three sample locations per feature)
  - 12 surface sediment sample locations (one sample from river sediments upgradient from geomorphic features being evaluated)

The PCOI identification samples and reference area samples will be analyzed for the target analyte list (TAL) identified in Section 4, grain size, and total organic carbon (TOC). The 8-year Floodplain boundary samples, Area 3 and Confluence Area samples, and geomorphic feature samples will be analyzed for polychlorinated dibenzo-p-furans (furans) and polychlorinated dibenzo-p-dioxins (dioxins), grain size, and TOC. Fractionated grain size samples will be analyzed for furans, dioxins, and TOC.

In addition to the sampling and analysis program presented above, event-based monitoring is ongoing (as described in the Tittabawassee River Floodplain Scoping Study Work Plan). Monitoring includes the flow and solids monitoring program, which consists of level

sensing, flow monitoring, and solids monitoring, and the periodic measurement of sediment deposition on turf mats and clay marker pads deployed within the study area.

## Field Methods and Procedures

This section describes the methods and procedures for collection of samples for laboratory analysis and collection methods for other types of data.

### Sample Containers and Preservatives

Sample containers, preservatives, and analytical methods for constituents on the TAL are provided in the *Quality Assurance Project Plan* (QAPP) dated December 2005 (CH2M HILL, 2005b).

### Sample Collection and Field Measurements

Access agreements and utility clearances will be obtained prior to field mobilization for each sample location.

The general approach for sample collection consists of the following activities:

1. Transport sampling equipment and samplers to the sample locations.
2. Confirm the horizontal location of the sampling station using a differential global positioning system (DGPS) (refer to Standard Operating Procedure [SOP] 1.7 *Global Positioning System Data Coordinate Location*) (CH2M HILL, 2005a).
3. Collect surface soil samples and soil cores, as described in following sections.
4. Segment cores into subsurface sample intervals.
5. Homogenize samples.
6. Transfer samples to appropriate holding containers and/or laboratory bottles (refer to SOP 6.1 *Sample Coordination Procedures*) (CH2M HILL, 2005a).
7. Prepare field sampling records, documentation, and shipping instructions (refer to SOP 7.3 *Field Documentation*) (CH2M HILL, 2005a).
8. Decontaminate sampling equipment (refer to SOP 5.1 *Field Decontamination Procedures*) (CH2M HILL, 2005a).
9. Manage investigation-derived waste (IDW) (refer to SOP 5.2 *Handling and Disposal of Investigation-Derived Waste*) (CH2M HILL, 2005a).
10. Ship samples to the laboratory (refer to SOP 6.2 *Sample Handling and Shipping Custody Procedure*) (CH2M HILL, 2005a).

### Surface Soil Samples

Surface soil samples (0 to 0.5-foot-depth interval) will be obtained using a hand auger or hand tools. The soil in the hand-auger bucket will be placed in an aluminum pan (or stainless steel bowl) and homogenized using a stainless steel spoon prior to filling sample

jars. Decontaminated or disposable equipment will be used to collect and homogenize soil and transfer it to appropriate sample containers. All equipment will be decontaminated or disposed of between sample locations.

For some surface samples, multiple auger cores will be necessary to fulfill the required analyses. These auger corings should be collected and homogenized together as necessary. If multiple auger corings are necessary, the corings should be no more than 6 inches apart. Sampling locations where multiple corings are taken should be noted by the field team and recorded in the field notebook. Excess soil not used for laboratory analysis should be placed back at the sampling location from which it was removed. If additional soil is required to complete filling the auger hole the sampling location will be backfilled to grade with soil approved by the Field Team Leader. Surface sampling procedures are detailed in the following SOPs (CH2M HILL, 2005a):

- SOP 2.1 *Manual Soil Sampling*
- SOP 2.7 *Soil Classification and Logging*

### Subsurface Soil Samples

Subsurface soil samples will be collected from soil cores taken at selected locations using direct-push technology, hollow-stem auger, and split-barrel sampler, or vibracore. The soil cores will be segmented into 0.5-foot (upper three feet) and one-foot (remainder of core) intervals. Some subsurface locations will require multiple borings to the same depth to attain the minimum amount of soil for laboratory analysis, soil taken from these borings should be collected and homogenized together as necessary. If multiple borings are necessary, they should be no more than six inches apart. Sampling locations where multiple borings are taken should be noted by the field team and recorded in the field notebook.

Each core segment will be extruded into a separate aluminum pan (or stainless steel bowl). The extruded core segment will then be homogenized using a stainless steel spoon prior to filling sample jars. Decontaminated or disposable equipment will be used to collect soil and transfer it to appropriate sample containers. Excess soil not used for laboratory analysis will be placed back into the sampling location from which it was removed. Bentonite will be used to abandon the sampling location. The bentonite will be hydrated to account for expansion. If additional soil is required to complete filling the auger hole the sampling location will be backfilled to grade with soil approved by the Field Team Leader. Sub-surface drilling and sampling procedures are detailed in the following SOPs (CH2M HILL, 2005a):

- SOP 2.3 *Drilling and Sampling Using Direct Push Techniques*
- SOP 2.7 *Soil Classification and Logging*

### Sediment Sampling

Lexan tubing will be the primary equipment used to collect sediment cores. The Lexan tube will be pushed into the sediment by hand until refusal. If sufficient penetration cannot be achieved using Lexan tubing (perhaps because of the presence of cobbles, bedrock or other hard consolidated material), a suitable sediment corer may be substituted where necessary and practicable. The core tubing will be inserted down into the sediments in a straight and vertical manner to provide a representative cross-section sample.

If the sediment sample is solely for the purpose of descriptive physical characterization, it may be removed from the water/core, described and disposed of at the sampling location. If the sediment sample is to be transported to another location for processing, the core sample will be properly capped and sealed for transport.

Sediment cores for laboratory analysis will be extruded from the Lexan tubing onto an aluminum or stainless steel tray or onto aluminum foil. Cores will be sectioned into the required depth-proportioned increments based on the ratio of the measured sediment depth to the recovered sediment depth to account for sample compression or expansion during collection. The soil cores will be segmented into 0.3-foot intervals for the foot and one-foot (remainder of core) intervals. Each increment will be individually packaged.

For sediment depth/thickness probing, the tubing may be replaced with a calibrated rod. The rod will be pushed into the sediment by hand until refusal and the depth of the sediment will be measured.

Procedures for obtaining sediment samples from rivers, creeks, ponds and impoundments are detailed in SOP 3.1 *Core Sediment Sampling* (CH2M HILL, 2005a).

### Surface Water Sampling

A hand-held depth-integrating suspended-sediment sampler will be used to collect surface water samples for analysis. The sampling equipment will be calibrated to sample isokinetically. An isokinetic sampler collects water sample from a river at a rate such that the velocity in the intake nozzle is equal to the incident stream velocity at the nozzle entrance. The sample collected is proportional to the instantaneous stream velocity at the intake nozzle and is therefore representative of the sediment load at that point (USGS, 2005). For Tittabawassee River sampling, a US DH-76 or similar sampler will be employed. The DH-76 is a medium-weight hand-line suspended-sediment sampler. The sampler can be lowered and raised, hand-over-hand, with a flexible suspension line. It can be used in streams with depths up to 15 feet and in-stream velocities ranging from 1.5 to 6.6 feet per second (ft/sec).

Surface water sampling procedures are detailed in the following SOPs (CH2M HILL, 2005a):

- SOP 4.1 *Surface Water Sampling – General Procedures*
- SOP 4.2 *Clean Sampling for Trace Metals in Surface Water*

### High Flow Event Automatic Sampling

The high flow sampler is an automated submersible pump sampling system that is activated and deactivated by float switches triggered by flood water level and sample container water volume, respectively. When the pump activation float switch is triggered, the pump transfers flood water into the sample container until the pump deactivation float switch (installed inside the sample container) is triggered. The high flow samplers will be installed with security devices to thwart tampering. After installation, the samplers will be inspected, tested and maintained to ensure they remain in operable condition. After the high flow samples have been collected by the samplers, the samples will be retrieved, documented and submitted under strict chain-of-custody for laboratory analysis. Installation and operation procedures for high-flow automated sampling equipment are detailed in SOP 4.6 *High-Flow Automatic Sampling* (CH2M HILL, 2005a).

### Clay Pad Deployment and Coring

Clay pads serve as a clean surface on which solids may be deposited and periodic samples can be collected from the pads to provide some measure of the amount of solids deposited on the floodplain at various locations along the length of the river. White feldspar clay pads will be installed and cores will be collected from the pads following solids deposition during flood events. A GPS unit will be used to locate the position of the clay pad based on proposed coordinates. A 20-inch by 20-inch wooden frame will be orientated in a north-south direction. Using a sifter, 8 lbs. of feldspar clay will be spread over the area in the frame to a thickness that obscures groundcover. Water from a sprayer will be used to smooth out the clay. Four steel stakes will be pounded into the ground 2 inches from each corner of the clay pad to allow the location to be found in the future, using a metal detector.

Core samples will be collected from a previously uncored portion of the pad using a  $\frac{3}{4}$ -inch Shelby-type tube sampler. A wire mesh grid will be used to subdivide the clay pad into a 10 X 10 grid of 2-inch squares, numbered from 1 to 100. This will determine the previously cored cells. After measurement of the amount of solids on the pad, the core will be replaced into the hole from which it was taken to prevent collapse of surrounding sediment. Clay pad installation and coring procedures are detailed in SOP 3.7 *Clay Pad Deployment and Coring* (CH2M HILL, 2005a).

### Turf Mat Deployment and Sampling

Artificial turf mats will help determine furan and dioxin concentrations that accompany sediment accretion after single flooding events and/or flooding seasons. A turf mat will be installed adjacent to each clay pad. The mats will be oriented in a north-south direction, 3.3 feet east of each clay pad. The mats will be anchored with several steel pins pushed into the ground such that the mat conforms to the shape of the ground surface. The steel pins also serve to facilitate future recovery using GPS and a metal detector.

Sediment samples will be collected at the turf mats by cutting along the edge and clearing away enough solid from the edge to lift the mat without interference. The mat and sediment will be placed in a ziploc bag for sampling. The hole where the mat and sediment were removed will be replenished with native sand/soil and a new turf mat will be placed onto the new soil elevation. Turf mat installation and sampling procedures are detailed in SOP 3.6 *Artificial Turf Mat Deployment and Sampling* (CH2M HILL, 2005a).

### Geochronological Sampling

Floodplain soil cores will be collected and segmented for geochronological analysis of Cesium-137 and Lead-210, to support vertical dating of floodplain sediment and estimation of accumulation rates. Samples will be collected using a two-step method. For collection of the top 12 inches, a stainless steel open-ended box (8-inches long by 8-inches wide by 12-inches deep) is driven into the ground at each location after removal of surface vegetation/debris, and identified sample material is collected from within. A stainless steel ruler is used in conjunction with the boxes to identify sample intervals during collection. Half-inch-depth intervals are collected to 6 inches; 1-inch intervals are collected from 6 inches to 12 inches by scraping soil using a decontaminated stainless steel spoon. If the presence of a root prevents collection of a known volume, it will be noted in the field logs and the soil volume for that interval will not be considered during data evaluation.

The second step of the geochronological soil sampling process involves advancing a 4-inch-diameter Lexan tube with a fence-post driver to a depth of approximately 3 feet bgs centered inside the previously excavated stainless steel box. It will then be removed by using a post-hole digger to excavate a hole to first remove the stainless steel box and then the Lexan tube. Upon retrieval, excess tubing will be removed and the Lexan tube will be capped and secured with duct tape. Coring and sampling procedures are detailed in SOP 2.13 *Collection of Soil/Sediment Samples from Fine Depth Intervals* (CH2M HILL, 2005a).

### Dendrogeomorphic Measurements

The predetermined location for testing will be identified using GPS. The location for trees is identified as a zone within a distance of 100 feet from an existing clay pad or geochronological core location, following the local elevation contours. Within the zone, six trees of suitable species type will be identified such that there are:

- 3 trees from dominant canopy (tallest trees)
- 3 trees from subcanopy (canopy is below the canopy of tallest trees)

The lateral roots will be uncovered by excavating all soil down to the top of the basal flare in a radius of 3 to 5 feet around the entire tree starting on the outside and working towards the tree. To find a root, a metal rod or spade will be used to tamp around the tree base. When sound and resistance indicates a tree root is found, it will be followed to determine whether it comes from the tree in question. If the root is solid and flare is evident, it is highly probable that it is a basal root. The depth of 3 basal roots from top of root to soil surface will be measured at 3 to 5 feet away from trunk.

Three cores will be taken from the tree trunk just above the basal flare with an increment borer. Each core will be placed into a plastic straw to prevent coiling. The circumference of the tree will be measured at the same elevation as the cores. Procedures for selecting and coring trees and measuring tree root depth are detailed in SOP 2.14 *Dendrogeomorphic Measurement for Long Term Floodplain Accretion* (CH2M HILL, 2005a).

### Level Sensing

Automated water level sensor data loggers will be downloaded at installation locations along the Tittabawassee River. The data generated can be used to characterize water levels and determine stage-discharge relationships along the River. The level sensing devices incorporate pressure transducers and data loggers, allowing for continuous monitoring and recording of water levels at a 15-minute frequency. The devices will be inspected and downloaded from the data logger to a laptop computer on a biweekly basis. Downloaded data will be stored in a master database. Procedures for downloading water level sensor data are detailed in SOP 1.8 *Water Level Sensor Download* (CH2M HILL, 2005a).

## Field Equipment

### Required Supplies and Equipment

The requirements for supplies and equipment to be available to the field teams each field day are based on the type of operations being performed and are detailed in each activity's corresponding SOPs.

## Equipment Calibration and Procedures

The level of accuracy for GPS calibration is submeter, and detailed procedures are outlined in SOP 1.7 *Global Positioning Data Coordinate Location* (CH2M HILL, 2005a).

## Field QC Sample Requirements

Field quality control (QC) samples will be collected or prepared to assist in assessing data use. These QC samples include field duplicates, laboratory QC samples (for matrix spike [MS] and matrix spike duplicates [MSDs]), and temperature blanks. The QC samples will be collected immediately following, and using the same procedures as, the collection of the target sample. Field QC samples will be collected in accordance with Section 2.5 of the QAPP (CH2M HILL, 2005b).

## Equipment Decontamination Procedures

Decontamination procedures for sampling equipment that comes into contact with environmental media in the field will be performed. The field team will decontaminate reusable sampling equipment prior to commencement of sampling, between sample locations, and upon completion of the field activity. Separate sample processing equipment (that is, bowls, spoons, and trowels) will be dedicated to only one location per day and all materials that come into direct contact with sample materials will be decontaminated or disposed of. Disposable equipment will be used whenever possible to avoid potential cross-contamination and reduce generation of decontamination fluids. Specific procedures for decontamination are described in SOP 5.1 *Field Decontamination Procedures* (CH2M HILL, 2005a).

## Containment and Disposal of Investigation-Derived Waste

Rubbish, personal protective clothing, and other waste material will be collected and containerized promptly so that it does not leave the control of the project team and does not pose a slip/trip/fall hazard to team members.

Cuttings generated from the soil boring activities and water generated from decontamination may be disposed of onsite with approval from the property owners, as directed by the Field Team Leader; otherwise the IDW will be collected and placed in labeled 55-gallon steel drums.

For specific requirements of IDW handling, please refer to SOP: *Handling and Disposal of Investigation-Derived Waste* (CH2M HILL, 2005a).

## Sample Management Procedures and Documentation

This section identifies the procedures for management and documentation of samples from the time the samples are collected until they are shipped to the laboratory. To ensure that all samples are uniquely identified, the unique set of sample IDs will be maintained by the Sample ID Manager (SIM). The SIM will be responsible for distributing the sample IDs to the Project Manager(s) (PMs) and Field Team Leader(s) (FTLs) during Sampling and Analysis Plan (SAP) preparation and field activities. It is the responsibility of PMs and FTLs to ensure that the sample identification nomenclature is being used correctly throughout the project. If and when modifications to sample nomenclature need to be made due to changes in sampling design, it is the responsibility of the PM, FTL, and SIM to assure that these

modifications will create unique sample IDs that meet the requirements of the project database and meet the requirements detailed in SOP 6.1 *Sample Handling and Documentation Procedures* (CH2M HILL, 2005a).

### Sample Handling and Chain of Custody

The procedures used for proper packaging, shipping, and documentation of samples being transported from the field to the laboratory for analysis are given in SOP 6.1 *Sample Handling and Documentation Procedures* (CH2M HILL, 2005a). After samples are labeled and packaged, they will be shipped to the appropriate labs for analysis.

Completed chain-of-custody forms will be required for all samples. The chain-of-custody form will contain the sample's identification number, sample date and time, sample description, sample type, sample preservation, and analyses required. The original chain-of-custody form will accompany the samples to the laboratory. The forms will remain with the samples at all times. The samples and signed chain of custody forms will remain in the possession of the sampling crew until the samples are delivered to the express carrier.

### Sample Documentation

To ensure thorough recordkeeping, standardized forms and procedures will be used for recording field activities and sampling data. All sample field records, forms, and chain-of-custody records will be recorded in waterproof, indelible ink, and archived in the project files. If errors are made in any of these documents, field team personnel will cross a single line through the error and enter the correct information. All corrections will be initialed and dated by the personnel performing the correction. If possible, all corrections will be made by the individual who made the error.

### Daily Field Notebook Specifications

Field notes will be kept in bound daily field notebooks that are made with water-resistant pages, and notes will be taken with indelible pens when possible. In wet and rainy conditions, pencil entries are also acceptable if indelible pens are not functional.

All lines of all pages will be used to prevent later additions of text that may be questioned in legal terms. Any pages not used will be marked through with a line, the author's initials, and the note "Intentionally Left Blank" in accordance with SOP 7.3 *Field Documentation* (CH2M HILL, 2005a).

### Sample Notebook Entries

Sample notebooks will contain the preprinted forms that are designed to cue the field team to record all pertinent sample information. Sample information will be recorded following SOP 7.3 *Field Documentation* (CH2M HILL, 2005a). Samples will be collected at specific locations and assigned sample numbers in accordance with the sample numbering scheme. The following sample collection information will be documented in appropriate field forms:

- Description of the general sampling area, including site name.
- GPS coordinates.
- Station/location identifier.

- Description of the sample location. If DGPS coordinates are not available, the team member will try to estimate the location in comparison to two fixed points and draw a diagram in the field notebook indicating the sample location relative to these fixed points (include distances in feet).
- Sample matrix and type.
- Description of sample.
- Sample date and time.
- Sample identifier.
- Information on how the sample was collected.
- Number and type of sample containers collected.
- Record of any field measurements taken.

### Photographs

Photographs of sampling activities as specified in individual SOPs will be completed in accordance with SOP 7.1 *Digital Camera Use and Documentation Procedure* (CH2M HILL, 2005a).

## References

CH2M HILL. 2005a. Field Standard Operating Procedures. December

CH2M HILL. 2005b. Quality Assurance Project Plan. December.

United States Geological Survey (USGS). 2005. A Guide to the Proper Selection and Use of Federally Approved Sediment and Water-Quality Samplers. Open-file Report 2005-1087.